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Rodolia cardinalis (Mulsant) (Coleoptera: Coccinellidae), a new predator of *Crypticerya multicastrices* Kondo and Unruh (Hemiptera: Monophlebidae)

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Rodolia cardinalis (Mulsant) (Coleoptera: Coccinellidae), a new predator of *Crypticerya multicatrices* Kondo and Unruh (Hemiptera: Monophlebidae)

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Abstract. The Colombian fluted scale (CFS), *Crypticerya multicatrices* Kondo & Unruh (Hemiptera: Monophlebidae) is a polyphagous scale insect which affects about 100 species of plants. Between 2010–2013, the species was reported as an invasive pest on the islands of San Andres and Old Providence, Colombian territory in the Caribbean sea. Currently, populations of the CFS also have increased in the city of Cali, Valle del Cauca State, mainland Colombia, affecting different host plants, especially leguminous trees such as *Caesalpinia peltophoroides* Benth., *Pithecellobium dulce* (Roxb.) Benth., *P. saman* (Jacq.) Benth. (Fabaceae) and mango, *Mangifera indica* L. (Anacardiaceae). With the aim of searching for natural enemies to control the CFS, field studies were conducted in the city of Cali between February 2013 and October 2014. As a result of this study, two species of lady beetles were found feeding on CFS, i.e., *Anovia punica* Gordon and *Rodolia cardinalis* (Mulsant) (Coleoptera: Coccinellidae). This is the first record of *R. cardinalis* preying on CFS.

Key words. *Anovia punica*, biological control, Colombia, ladybeetles, natural enemies, predators, vedalia beetle.

Resumen. La cochinilla acanalada de Colombia (CAC), *Crypticerya multicatrices* Kondo & Unruh (Hemiptera: Monophlebidae) es un insecto polífago, que afecta unas 100 especies de plantas. La CAC fue reportada como plaga invasora en las islas de San Andrés y Providencia, territorio Colombiano ubicado en el mar Caribe, entre 2010–2013. Actualmente, este insecto escama también ha incrementado sus poblaciones en la ciudad de Cali, departamento del Valle del Cauca, en Colombia continental, afectando diferentes plantas hospedadoras, principalmente árboles leguminosos como *Caesalpinia peltophoroides* Benth., *Pithecellobium dulce* (Roxb.) Benth., *P. saman* (Jacq.) Benth. (Fabaceae) y *Mangifera indica* L. (Anacardiaceae). Con el objetivo de buscar enemigos naturales de la CAC, se realizaron estudios de campo en la ciudad de Cali entre febrero 2013 y octubre 2014. Como resultado de este estudio se encontraron dos especies de mariquitas depredando a la CAC, i.e., *Anovia punica* Gordon y *Rodolia cardinalis* (Mulsant). Este es el primer registro de *R. cardinalis* depredando a *C. multicatrices*.

Palabras clave. *Anovia punica*, Colombia, control biológico, depredadores, enemigos naturales, mariquitas, cucarrón vedalia.

Introduction

The Colombian fluted scale (CFS), *Crypticerya multicatrices* Kondo and Unruh (Hemiptera: Monophlebidae) is a polyphagous insect that affects about 100 species of plants, including fruit trees of economic importance (Kondo et al. 2012.). CFS is native to continental Colombia and, until now, it has

been reported only from Colombia, in the departments of Antioquia, Caldas, Cordoba, Magdalena, Nariño, San Andres and Old Providence, Tolima and Valle del Cauca (González and Kondo 2014). Between 2010–2013, this species was reported as an invasive pest on the islands of San Andres and Old Providence (ICA 2010; Kondo et al. 2012.).

Several natural enemies of *C. multicastrices* have been reported in the scientific literature as follows: **Coleoptera: Coccinellidae:** *Delphastus quinculus* Gordon, *Diomus seminulus* (Mulsant) (González et al. 2012.), *Anovia punica* Gordon, 1972 (González and Kondo 2014; Kondo et al. 2014, as *Anovia* sp.); **Diptera: Phoridae:** *Syneura cocciphila* (Coquillett) (Gaimari et al. 2012); **Hymenoptera: Encyrtidae:** 2 morpho-species (Kondo et al. 2012, 2014), one which appears to be a hyperparasitoid identified as *Cheiloneurus* sp. (Kondo et al. 2014); **Neuroptera: Chrysopidae:** *Chrysoperla* sp. and *Ceraeochrysa* sp. (Kondo et al. 2014). **Eurotiales: Trichocomaceae:** *Isaria* sp. (Kondo et al. 2012, 2014; Silva-Gómez et al. 2012).

Currently, outbreaks of the CFS are occurring in the city of Cali, affecting urban trees such as *Caesalpinia peltophoroides* Benth., *Pithecellobium dulce* (Roxb.) Benth. and *P. saman* (Jacq.) Benth. (Fabaceae) and mango *Mangifera indica* L. (Anacardiaceae). Field surveys were conducted in the city of Cali with the aim of finding effective natural enemies for this new urban pest. As a result, two ladybeetles (Coleoptera: Coccinellidae) were found preying upon *C. multicastrices*, namely, *Anovia punica*, a species recently reported as an effective natural enemy of *C. multicastrices* in the city of Cali and on San Andres island (González and Kondo 2014), and the vedalia beetle, *Rodolia cardinalis* (Mulsant, 1850), which is herein reported for the first time as a natural enemy of *C. multicastrices*.

Materials and methods

A field survey of natural enemies was conducted in the urban area of the city of Cali, in the State of Valle del Cauca, Colombia, between February 2013 and October 2014. Collecting was focused on leguminous urban trees, mainly on leguminous trees such as *C. peltophoroides*, *P. dulce*, *P. saman* and mango, *M. indica* infested with *C. multicastrices* which showed signs of predation. The most infested branches of *C. multicastrices* were cut using clippers and were placed in plastic containers. Location data was recorded at each sampled point. The coordinates (latitude and longitude) and altitude data was taken with a GPS Garmin eTrex model 10. In the laboratory, samples were transferred to Petri dishes to facilitate observations of natural enemies of *C. multicastrices*, e.g., confirmation of predation.

Specimens of *A. punica* were identified based on characteristics of the genitalia (Gordon 1972; González and Kondo 2014) and on external morphology (González and Kondo 2014). The identification of *A. punica* was made by comparison of the genitalia, since the species presents great variability in its external appearance, making it a difficult species to identify (González and Kondo 2014). In their study, González and Kondo (2014) reported on the external variations of *A. punica* and expanded its known geographical distribution to Peru. The other taxon, *Rodolia cardinalis* is an emblematic species easily characterized by its color patterns and morphology, thus specimens collected in Colombia that were found associated with *C. multicastrices* were identified by comparison with specimens of *R. cardinalis* from Chile, Argentina, Peru and Venezuela which are held at the third authors personal collection.

Anovia and *Rodolia* are so similar that several authors have suggested that they should be synonymized, including Forrester (2008) in a non-valid publication, but later Forrester et al. (2009) recognized them as different genera. *Rodolia cardinalis* can be recognized by a complex design composed of six spots and black edges on a red background, and all species of *Anovia* are of a single color or have concentric markings in the shape of a complete or partial circle or ring that runs along both elytra (e.g., see González and Kondo 2014).

Extraction of genitalia and species identification of the two species of coccinellids was carried out by the third author. The genitalia of the coccinellids were extracted by macerating the abdomens in 10% KOH solution inside a glass tube submerged in hot water for 20–30 minutes, and later washed with distilled water. Components of the genitalia were separated under the microscope using insect pins and mounted in glycerin on glass slides in order to study the important morphological features. For subsequent storage, the genitalia were put into micro vials filled with glycerin and attached to the insect pin of the specimen from which they were extracted. Both male and female specimens were dissected.

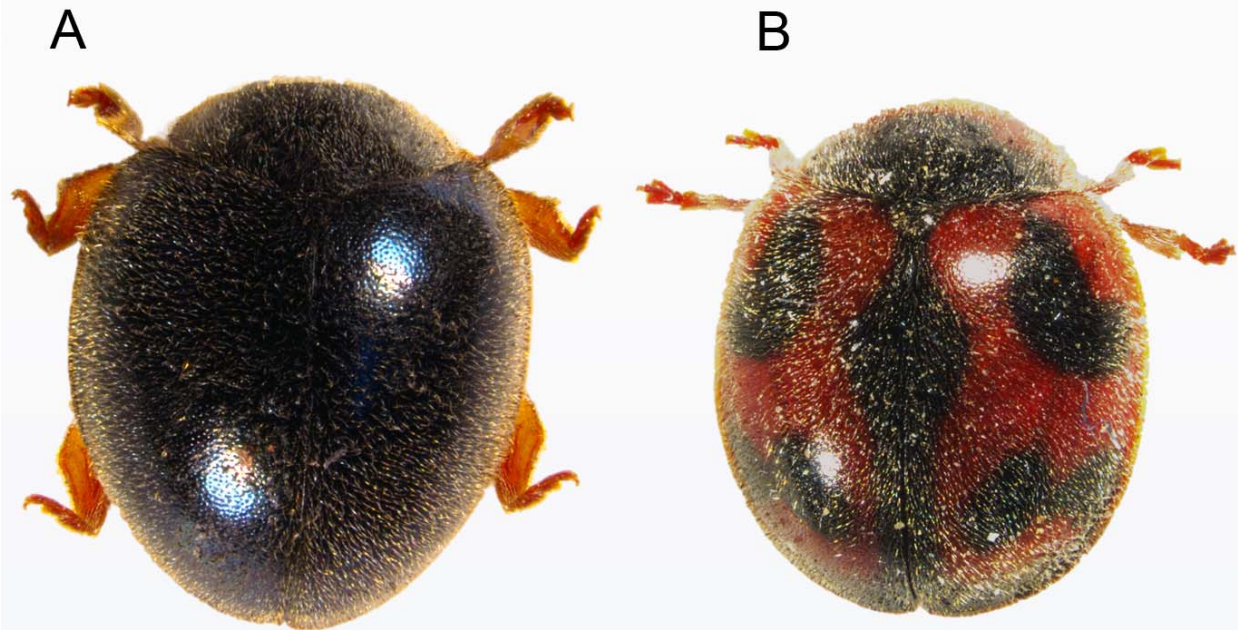


Figure 1. A. *Anovia punica*. Bluish-dark specimen from Cali. **B.** *Rodolia cardinalis*, with typical patterns. Photos by C. Pinchao.

Alcohol material is deposited at the Museo de Entomología, Corporación Colombiana de Investigación Agropecuaria, Centro de Investigación Palmira, Palmira, Valle del Cauca, Colombia (**MECP**), each vial contains from 1–10 specimens; specimens which were dissected for identification are deposited at the Guillermo González Personal Collection, Santiago, Chile (**GGPC**).

Results and discussion

Two species of ladybeetles (Coleoptera: Coccinellidae) were found preying on nymphs and eggs of *C. multicastrices*, namely, *Anovia punica* (Fig. 1A) and *Rodolia cardinalis* (Fig. 1B).

Species of *Anovia* Casey and *Rodolia* Mulsant are present in South America. *Anovia* is a genus endemic to the Americas, with six species known to date, and only two known to occur in South America, namely *A. punica* and *A. peruviana* (Gordon 1972). On the other hand, *Rodolia* is an Old World genus which is mainly distributed in tropical and subtropical areas of Oceania, Asia and Africa, and includes about 40–60 species (Forrester 2008), two of which species have been introduced into the Americas, namely *R. koebelei* (Coquillett, 1893) and *R. cardinalis*. However, *R. koebelei* which was introduced to California in 1891 from Australia did not get established (Gordon 1985). In Colombia, *R. cardinalis* was introduced by entomologist Luis M. Murillo in 1948 in the city of Bogotá to control the cottony cushion scale, *Icerya purchasi* Maskell, then known as “cochinilla acanalada de las acacias” [acacia fluted scale] and called the “Peste Blanca” [white plague] due to its heavy damage to street trees (Valenzuela 1993).

Anovia punica Gordon

Larvae and adult (Fig. 1 A) beetles of *A. punica* were collected and found feeding on CFS in the city of Cali. *Anovia punica* was originally described from Venezuela (type locality), Colombia, Honduras, Panama and Trinidad (Gordon 1972) and have been more recently recorded from Peru (Gonzalez and Kondo 2014). This insect has been identified amongst material collected in Colombia and associated with the Colombian fluted scale, *C. multicastrices* (Gonzalez and Kondo 2014). In the original description, three color forms of *A. punica* were described, namely: 1) reddish purple with edges of elytra and pronotum red; 2) completely red; and 3) red with black lateral band by Gordon (1972). More recently, Gonzalez and

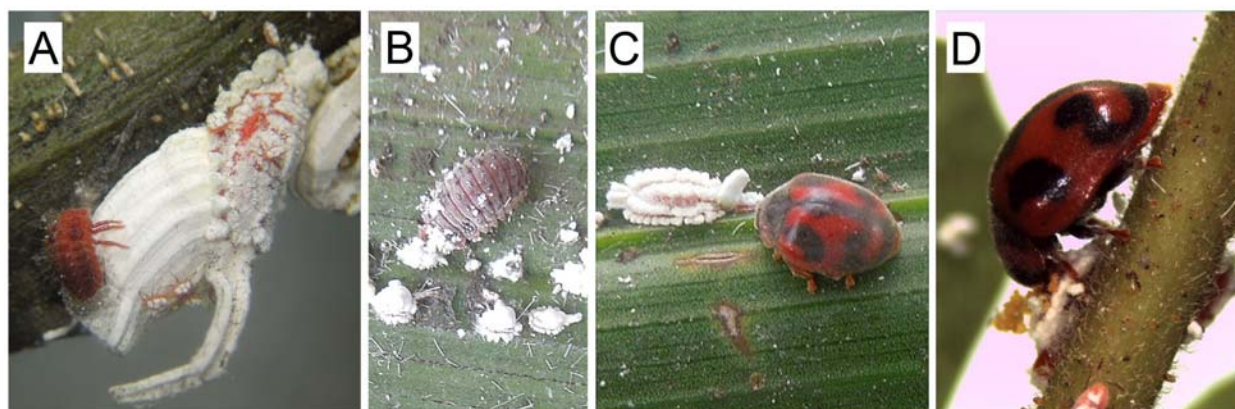


Figure 2. A. Larva of *Rodolia cardinalis* on ovisac of *Crypticeria multicastrices*. B. Larva of *R. cardinalis* feeding on *C. multicastrices* nymph. C. Adult of *R. cardinalis* next to a third-instar nymph of *C. multicastrices*. D. Adult *R. cardinalis* feeding on nymph of *C. multicastrices*.

Kondo (2014) reported further color morphs for this coccinellid. They reported that the predominant color can be light brown, dark brown, purple, black opaque or black with tinges of shiny green or blue, with color patterns composed of reddish or brown areas on black background or black areas on brown or reddish background (Gonzalez and Kondo 2014). According to Gonzalez and Kondo (2014), these patterns are usually seen on the front edge and the lateral 1/3rd of the pronotum, scutellum, and lateral edges of the elytra. The color patterns of *A. punica* may form a marginal or submarginal band of variable width and length on the elytra or sometimes found at the basal area of the elytra near the scutellum (Gonzalez and Kondo 2014). Based on observations in the present study, both larvae and adults of *A. punica* prefer eggs of CFS for feeding, but will feed on other nymphal stages of CFS.

The vedalia beetle, *Rodolia cardinalis* (Mulsant)

Larvae (Fig. 2A, B) and adult beetles (Fig. 1B, 2C, D) of *R. cardinalis* were found feeding on the Colombian fluted scale, *C. multicastrices* in the city of Cali. The vedalia beetle, *R. cardinalis* is well known for being the key natural enemy involved in the first successful case of classical biological control, used to control the cottony cushion scale, *Icerya purchasi* Maskell (Hemiptera: Monophlebidae) in California, in the 1880s and subsequently introduced into 60 countries (Caltagirone and Douth 1989). In general, the host range of this insect is restricted to scale insect (Hemiptera: Coccoidea) species in the families Dactylopiidae, Diaspididae, Monophlebidae and Pseudococcidae (Causton et al. 2004).

In 2002, *R. cardinalis* successfully controlled the invasive species *I. purchasi* in the Galapagos Islands (Calderon-Alvarez et al. 2012). Similar to the case of *R. cardinalis*, in 2013, *A. punica* (as *Anovia* sp.) dramatically decreased populations of *C. multicastrices* just eight months after it was first observed on the island of San Andres (Kondo et al. 2014). Both nymphs and adults of *R. cardinalis* feed on eggs and nymphs. No predation on adult CFS was observed and further studies are needed to confirm whether *R. cardinalis* will feed on the adult stage. In the city of Cali, *A. punica* and *R. cardinalis* are commonly collected in association with CFS and may constitute important natural enemies that control populations of *C. multicastrices*. Of the two species of coccinellids found in the present study, *A. punica* appears to be more commonly associated with CFS.

Material examined

Anovia punica Gordon.

COLOMBIA: Valle del Cauca: Cali: 03°27'24.5"N, 76°29'22.313"W, 11.ii.2013, 989 m asl, ex *Pithecellobium dulce* (1 specimen) (GGPC); **Cartago,** 04°44'23.89"N, 75°54'24.073"W, 934 m asl, 15.xi.2013, coll. M. Manrique

and A. Arias, ex. feeding on *C. multicatrices* found on palm (1 female) (GGPC); 03°27245.73N, 76°2922.313W, 11.ii.2013, coll. E.M. Quintero, ex. feeding on *C. multicatrices* found on *Pithecellobium dulce* (5 unsexed specimens) (GGPC); Makro de la 1ra, 03°27254.83N, 76°30252.23W, 987 m a.s.l., 17.ii.2014, coll. X. Montealegre; same data, except coll. C. Pinchao; Av. Sexta, Chipichape, 03°28241.43N, 76°31232.23W, 988 m a.s.l., 17.ii.2014, coll. X. Montealegre; same data, except 11.iii.2014, coll. K. Muñoz; same data except, coll. X. Montealegre; same data except, coll. C. Pinchao; Carrera 1ra con Calle 12, La Ermita, 03°27225.83N, 76°32210.23W, 1013 m a.s.l., 29.iv.2014, coll. X. Montealegre; Carrera 1ra, Parque la Ermita, 03°27220.63N, 76°31254.53W, 1001 m a.s.l., 13.v.2014, X. Montealegre; Calle 26 con Carrera 44, Barrio Villa del Sur, 03°24252.83N, 76°31228.73W, 970 m a.s.l., 01.vii.2014, coll. C. Pinchao; Carrera 39 con Calle 13B, CC Balcón de Las Lajas, 03°25207.43N, 76°31243.53W, 987 m a.s.l., 01.vii.2014, coll. X. Montealegre; Carrera 44 con Calle 15A, Las Granjas, 03°24244.23N, 76°31231.73W, 978 m a.s.l., 22.vii.2014, coll. X. Montealegre; Bomba Texaco, Av. Simon Bolivar, Calle 25 con Diag. 66, 03°23253.53N, 76°31223.93W, 974 m a.s.l., 12.ix.2014, coll. X. Montealegre; same data except 16.ix.2014; same data except 21.x.2014; Coliseo María Isabel Urrutia, Calle 26 con Cra. 50, 03°24223.03N, 76°31218.93W, 970 m a.s.l., 02.x.2014, coll. K. Muñoz; same data except 07.x.2014; Calle 19 con Cra. 44, Barrio San Judas, 03°24243.13N, 76°31224.33W, 977 m a.s.l., 09.x.2014, coll. X. Montealegre; Prados del Norte, Av. 3ra Norte, 03°28227.13N, 76°31210.33W, 981 m a.s.l., 17.ii.2014, coll. K. Muñoz; Av. Del Rio, Parque del Gato, 03°27203.83N, 76°32234.043W, 1027 m a.s.l., 17.ii.2014, coll. K. Muñoz; Av. 5ta con Cra. 86, 03°22248.53N, 76°32236.03W, 1000 m a.s.l., 25.ii.2014, coll. C. Pinchao; same data except coll. K. Muñoz; Av. Ciudad de Cali, Cruce Navarro con autopista sur, 03°24223.63N, 76°31217.53W, 981 m a.s.l., 25.ii.2014, coll. X. Montealegre; Av. Del Rio, Calle 5 Norte, 03°272053N, 76°32217.13W, 1022 m a.s.l., 04.iii.2014, coll. K. Muñoz; Mirador Belalcazar, 03°26257.43N, 76°32243.33W, 1081 m a.s.l., 04.iii.2014, coll. X. Montealegre; Av. Del Rio, Cra. 1ra C Oeste, 03°27216.93N, 76°32258.13W, 1036 m a.s.l., 11.iii.2014, coll. C. Pinchao; Av. Del Rio, Parque del Gato, 03°27203.83N, 76°32234.043W, 1027 m a.s.l., 11.iii.2014, coll. K. Muñoz; Av. Del Rio, Parque del Gato, 2da oeste, 03°27215.13N, 76°32243.83W, 1046 m a.s.l., 11.iii.2014, coll. X. Montealegre; Parque del Gato Ventolini, 03°27203.83N, 76°32234.043W, 1027 m a.s.l., 25.iii.2014, coll. C. Pinchao, Cra. 56 con Calle 5 (McDonalds), 03°24242.33N, 76°33201.43W, 1015 m a.s.l., 18.iii.2014, coll. K. Muñoz; Av. 5 con Cra. 85, 03°23202.03N, 76°32248.63W, 1007 m a.s.l., 18.iii.2014, coll. X. Montealegre; Calle 9 con Cra. 36, Canchas Panamericanas, 03°25240.43N, 76°32228.53W, 982 m a.s.l., 18.iii.2014, C. Pinchao; Estación de Policia La Flora, 03°28204.23N, 06°31234.73W, 990 m a.s.l., 25.iii.2014, K. Muñoz; Av. 6ta con 34, Centro Comercial La 14, 03°28229.23N, 76°31247.93W, 989 m a.s.l., 25.iii.2014, coll. X. Montealegre; Av. 6ta con Calle 24, Supermercado Super Inter, 03°28208.23N, 76°3220.073W, 1006 m a.s.l., 25.iii.2014, coll. K. Muñoz; same data except coll. X. Montealegre; Av. 4ta con Calle 12 Norte, Plazoleta Jairo Varela, 03°27220.03N, 76°3221.83W, 1008 m a.s.l., 08.iv.2014, C. Pinchao; Cra. 4ta C con Calle 2 Oeste, Parque San Antonio, 03°26251.63N, 76°32229.53W, 1066 m a.s.l., 08.iv.2014, coll. X. Montealegre; Cra 25 con Calle 4ta, San Fernando Viejo, 03°26220.33N, 76°32240.53W, 977 m a.s.l., 22.iv.2014, coll. C. Pinchao, Cra. 1ra con Calle 12, La Ermita, 03°27225.73N, 76°32210.23W, 1018 m a.s.l., 22.iv.2014, coll. C. Pinchao; Cra. 42 con Calle 6, Nuevo Tequendama, 03°25211.63N, 76°32233.53W, 973 m a.s.l., 13.v.2014, coll. C. Pinchao; Autopista Sur calle 63, 03°26237.73N, 76°29231.23W, 971 m a.s.l., 03.vi.2014, coll. X. Montealegre; Autopista Sur Oriental con Cra. 39, 03°25236.03N, 76°32216.43W, 975 m a.s.l., 10.vi.2014, K. Muñoz; Cra. 25 con Calle 19, Las Acacias, 03°26206.43N, 76°31230.43W, 987 m a.s.l., 17.vi.2014, coll. X. Montealegre; La Floresta, Calle 70 con Cra. 28, 03°26200.13N, 76°30204.53W, 968 m a.s.l., 24.vi.2014, C. Pinchao; Calle 26 con Cra. 47B, Villa del Sur, 03°24235.43N, 76°31231.53W, 978 m a.s.l., 24.vi.2014, coll. K. Muñoz; Autopista sur-oriental con Cra. 36, Barrio Olímpico, 03°25223.13N, 76°32205.43W, 984 m a.s.l., 08.vii.2014, coll. C. Pinchao; Cra. 44 con Calle 15A, Las Granjas, 03°24244.23N, 76°31231.73W, 978 m a.s.l., 22.vii.2014, C. Pinchao; Mariano Ramos, Cra. 46 con Calle 40, 03°24224.63N, 76°30256.03W, 969 m a.s.l., 07.x.2014, coll. X. Montealegre, La Floresta, Calle 70 con Cra. 28, 03°26200.13N, 76°30204.53W, 968 m a.s.l., 21.x.2014, coll. C. Pinchao.

Rodolia cardinalis (Mulsant)

COLOMBIA: Valle del Cauca: Cali: Makro de la 1ra, 03°27254.83N, 76°30252.23W, 987 m a.s.l., 17.ii.2014, coll. X. Montealegre; same data, except coll. C. Pinchao; Av. Sexta, Chipichape, 03°28241.43N,

76°31232.23W, 988 m a.s.l., 17.ii.2014, coll. X. Montealegre; same data, except 11.iii.2014, coll. K. Muñoz; same data except, coll. X. Montealegre; same data except, coll. C. Pinchao; Carrera 1ra con Calle 12, La Ermita, 03°27225.83N, 76°32210.23W, 1013 m a.s.l., 29.iv.2014, coll. X. Montealegre; Carrera 39 con Calle 9B, Canchas Panamericanas, 03°25215.83N, 76°32212.13W, 983 m a.s.l., 13.v.2014, coll. K. Muñoz; Carrera 1ra, Parque la Ermita, 03°27220.63N, 76°31254.53W, 1001 m a.s.l., 13.v.2014, X. Montealegre; Calle 26 con Carrera 44, Barrio Villa del Sur, 03°24252.83N, 76°31228.73W, 970 m a.s.l., 17.vi.2014, coll. K. Muñoz; Colombia, Calle 26 con Carrera 44, Barrio Villa del Sur, 03°24252.83N, 76°31228.73W, 970 m a.s.l., 01.vii.2014, coll. C. Pinchao; Carrera 39 con Calle 13B, CC Balcón de Las Lajas, 03°25207.43N, 76°31243.53W, 987 m a.s.l., 01.vii.2014, coll. X. Montealegre; Carrera 44 con Calle 15A, Las Granjas, 03°24244.23N, 76°31231.73W, 978 m a.s.l., 22.vii.2014, coll. X. Montealegre; Calle 26 con Cra. 44, Barrio Villa del Sur, 03°24252.83N, 76°31228.73W, 970 m a.s.l., 29.vii.2014, coll. K. Muñoz; Bomba Texaco, Av. Simon Bolivar, Calle 25 con Diag. 66, 03°23253.53N, 76°31223.93W, 974 m a.s.l., 12.ix.2014, coll. X. Montealegre; same data except 16.ix.2014; same data except 21.x.2014; Coliseo María Isabel Urrutia, Calle 26 con Cra. 50, 03°24223.03N, 76°31218.93W, 970 m a.s.l., 02.x.2014, coll. K. Muñoz; same data except 07.x.2014; Calle 19 con Cra. 44, Barrio San Judas, 03°24243.13N, 76°31224.33W, 977 m a.s.l., 09.x.2014, coll. X. Montealegre.

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